S24

New approach for the prediction of the *in vitro* digestibility of cooked plantain flour as a function of thermo-hydric conditions

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INTRODUCTION

The main component of plantain at green stage of maturity is starch containing a high proportion of resistant starch. A cooking process is needed for the consumption of plantain. This works aims to predict the in vitro digestibility of cooked plantain as a function of thermo-hydric conditions.

The combined effect of temperature (T) and water content (X_1) on the degree of starch gelatinization (α) was evaluated by DSC and modelled as a function of T and X_1, using the Weibull model. The rapidly digestible starch (*RDS*) and resistant starch (*RS*) fractions were predicted for different α values.

Plantain based-foods consumption

Water cooking « sancocho » and roasting

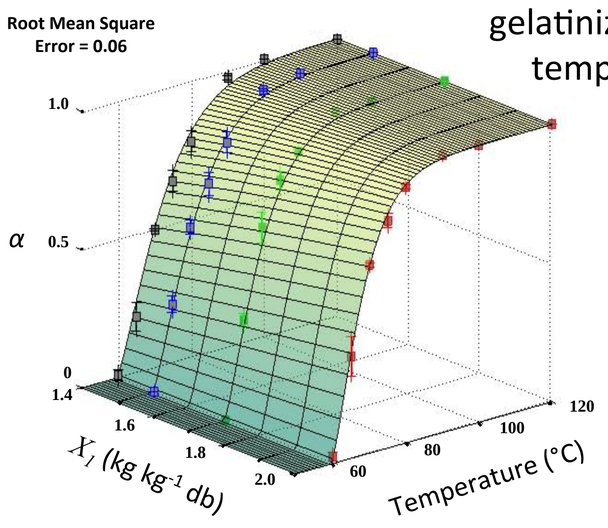

Fried and texturized products


« Coladas » and muffins products


RESULTS

Weibull model

Upon water content, the degree of starch gelatinization was expressed as a function of temperature T providing 3 parameters:



$$\alpha = 1 - exp\left[-\left(\frac{T-\theta}{\gamma}\right)^{\beta}\right] \quad Pour \;\; T > \theta$$

$$\alpha = 0 \quad Pour \;\; T \le \theta$$

$$\gamma = \frac{a_\alpha}{X_1}$$

Figure 1. Modelling state diagram of green plantain flour-water mixtures (starch gelatinization vs. treatment temperature and water content in db) as per Giraldo *et al*. 2015.

A 3-parameter Weibull model was fitted with DSC data for any water content (X_1)

Starch state diagrams

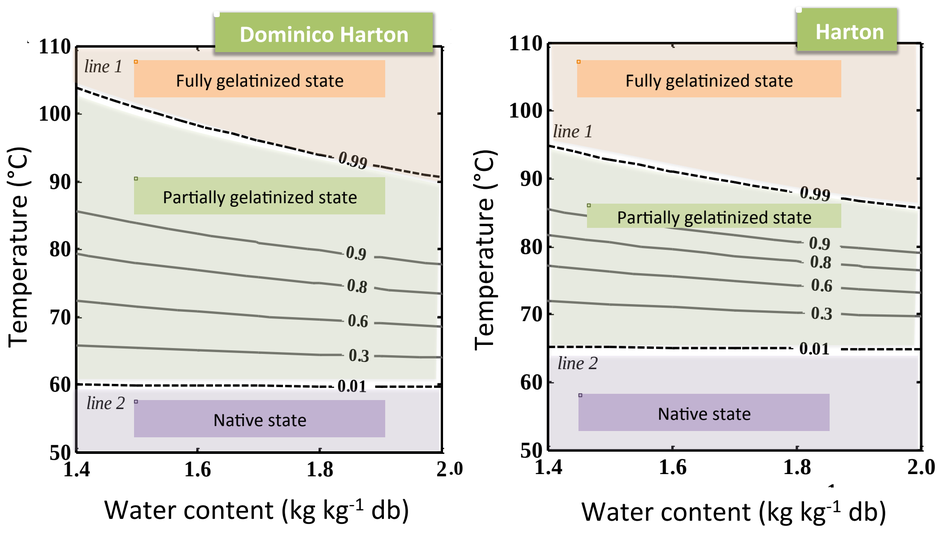


Figure 2. State diagram of plantain green banana flour-water mixtures for Dominico Harton and Harton genotypes

The extent of plantain starch gelatinization is dependent on temperature in such non-limiting water conditions

in vitro digestibility as a function of starch gelatinization

$$RDS^* = \frac{RDS - RDS_0}{RDS_1 - RDS_0} \qquad RS^* = \frac{RS - RS_0}{RS_1 - RS_0} \Rightarrow Y^* = \frac{1 - exp(-a\alpha)}{1 - exp(-a)}$$

Y** = *RDS** and *RS* ⇒ **Same equation was proposed for both *RDS* and *RS* fractions**

MATERIALS AND METHODS

Material

Plantain flour/water samples were prepared by mixing flour from two Colombian plantain genotypes with deionized water to reach water contents in the 1.4 – 2.0 kg kg^{-1} db range and kept for equilibrium under partial vacuum conditions.

Physicochemical analyses

Dry matter (AOAC, 1990), total starch content and free glucose using Holm (1985) with slight modifications, and starch digestibility (*RDS* and *RS*) (Englyst *et al*., 1996). Starch degree of gelatinization by Differential Scanning Calorimetry, DSC 7 Perkin-Elmer, Norwalk, VA.

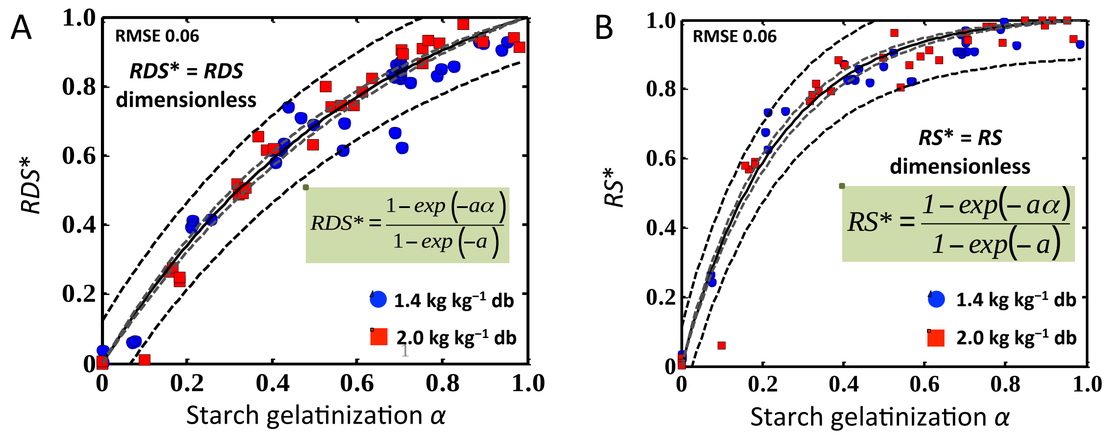
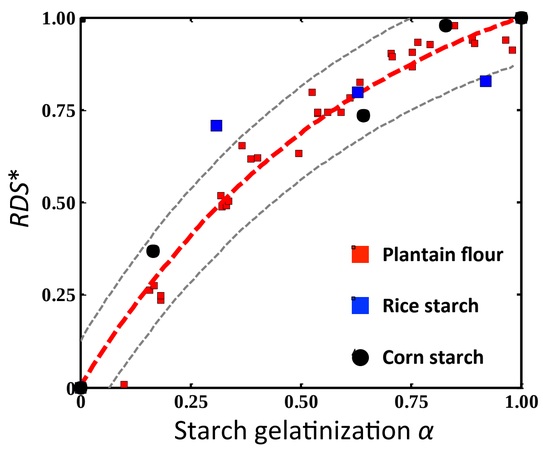


Figure 3. Dimensionless rapidly starch digestibility fraction (A) and resistant starch fraction (B) of plantain flour as function of starch gelatinization degree.

Starch gelatinization explained 95 % of the variation of *RDS**. A similar result was obtained for *RS**.

Comparison with some other starchy products



The two empirical models were reliable to predict *RDS* and *RS* as a function of α, and could be use for other starchy products

Figure 4. Comparison of the evolution of the *RDS* fraction with rice (Chung *et al*. 2006), corn (Miao *et al*. 2010) and plantain flour; red line: empirical exponential model for plantain flour

CONCLUSION

In the water content range of plantain (raw to cooked), a had slightly influence of X_1 was observed on α and digestibility properties. T is the main factor for its control. Digestibility starch fractions can be predicted by evaluating the extent of starch gelatinization. Some pre-gelatinized starches, could be obtained at intermediate cooking temperatures, while providing a low glycaemic impact.

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